Establishment of Bottomland Oak Plantations on the Yazoo National Wildlife Refuge Complex

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ABSTRACT. Stocking, height and diameter growth, and invasion of both herbaceous and woody plant species are reported for 5 direct seeded and 5 planted seedling stands of bottomland oaks, all of which were between 4 and 8 years old. Stocking was generally higher in the planted seedling stands. Both height and diameter growth were substantially higher in the planted seedling stands. Low stocking and poor growth, especially for the direct seeded stands, was associated with medium-textured soils and a heavy cover of Johnson grass (Sorghum halepense) *and goldenrod* (Solidago altissima). *Invasion of woody species was heavily dominated by light-seeded species, and was highest in stands close to mature trees.*

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The extensive clearing of bottomland hardwood forests in the lower Mississippi Valley for agricultural crop production has been well documented (Sternitzke 1976, MacDonald et al. 1979, Rudis and Birdsey 1986). Recently, however, several opportunities to restore some of these losses have arisen. Perhaps the best of these is the Conservation Reserve Program established under the 1985 Farm Bill (P.L. 100-233), which provides for cost-sharing of bottomland hardwood establishment on flood-prone croplands. Other opportunities exist as a result of the Water Resources Development Act of 1986 (P.L. 99-662), the North American Waterfowl Management Plan (Canadian Wildlife Service and U.S. Fish and Wildlife Service 1986), and the current Administration's policy of no net loss of wetlands.

To take full advantage of these opportunities, inexpensive methods of reforestation are required. Some researchers have indicated that planting of 1-0 nursery stock or direct seeding can work well for bottomland hardwood species planted on a variety of lower Mississippi Valley sites (Baker and Blackmon 1973, Johnson 1983, Johnson and Krinard 1985, 1987, Krinard and Kennedy 1987). However, in most situations these studies involved site preparation and post-planting weed control. Some of this research also seems to indicate that reforestation may work with little or no site preparation and weed control (albeit with reduced survival and growth), but this less intensive type of reforestation has not been thoroughly investigated, especially on old field sites.

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Reforestation with minimal site preparation and weed control is certainly not recommended for commercial forestry operations, but several state and federal wildlife conservation agencies have begun to apply these establishment methods on a relatively large scale. This type of reforestation appeals to such agencies because it offers an opportunity to re-establish a particularly valuable type of wildlife habitat (Wharton et al. 1981) with a minimal commitment of funds and manpower. The Louisiana Department of Wildlife and Fisheries, for example, has planted or direct-seeded over 3500 acres of bottomland oaks on the Ouachita Wildlife Management Area since 1985 (Larry Savage, Louisiana Department of Wildlife and Fisheries, pers. comm.). The U.S. Fish and Wildlife Service is also actively involved in bottomland hardwood re-establishment in the southeastern United States, and particularly in the lower Mississippi Valley (Haynes and Moore 1987).

Because of the large acreages of old field sites currently being planted using little or no site preparation and weed control, evaluations of the success being obtained by these methods are needed. In this paper, the stocking and growth of 10 stands of bottomland oaks established on old field sites by the U.S. Fish and Wildlife Service are reported. These plantations were established as part of normal refuge operations, rather than for research purposes, and may provide a realistic indication of the survival and growth of bottomland oaks that can be expected by natural resource agencies, farmers participating in the Conservation Reserve Program, and others reforesting similar sites without site preparation and weed control.

METHODS

Study Sites

This study was conducted on the Yazoo National Wildlife Refuge Complex, which consists of 5 National Wildlife Refuges located on the Mississippi-Yazoo Rivers alluvial plain in west-central Mississippi. Five stands of planted seedlings and five direct seeded stands were selected randomly from a total of 86 stands (totaling approx. 1700 acres) available on the 5 refuges.

Only stands 4 to 8 years old were selected. Younger stands were excluded because they were too young to evaluate growth. Only 3 of the 86 stands were older than 8 years; because these 3 stands were established with regular post-planting weed control, they are unrepresentative of most younger plantations and were therefore excluded. General characteristics of the 10 selected stands are presented in Table 1. Five species of oak were planted, including cherrybark (*Quercus pagoda*), Nuttall (*Q. nuttallii*), Shumard (*Q. shumardii*), water (*Q. nigra*), and willow (*Q. phellos*).

All of the selected stands were established without site preparation on fields that were in crop production for 10 or more years. Seed for the direct-seeded stands was collected locally by U.S. Fish and Wildlife Service personnel. Unsound acorns were eliminated using the float test. Sound acorns were stored either in water (Nuttall oak) or in buried burlap bags. Seedlings were bareroot 1-0 nursery stock. Most seedlings came from state nurseries in Louisiana and Mississippi; some were produced at a state nursery in Tennessee using acorns supplied by U.S. Fish and Wildlife Service personnel.

Stand 1 was planted by hand, Stands 2–5 were planted using a mechanical seedling planter, and Stands 6–10 were planted using a modified soybean planter. Only Stand 8 had any post-planting weed control, which consisted of bushhogging and an herbicide application between the rows during the first growing season.

Sampling of Individual Stands

The 10 stands were sampled between July 18 and September 15, 1989. Depending on the size and shape of each stand, from 1 to 3 transects were established in a direction perpendicular to the nearest stand of mature forest. Along each transect, 1/20-ac circular plots were established every 100 ft, beginning at the edge of the stand.

In each plot, all trees and shrubs taller than 3 ft in height were located and the species, dbh (when seedlings were tall enough), and height were recorded. Because the majority of seedlings in Stands 8, 9, and 10 were very small, all seedlings in these stands were recorded, regardless of height. Also, four 1-m^2 quadrats were set up in each plot to make visual estimates of herbaceous cover.

One goal of this sampling design was to establish enough plots for a sample of between 5 and 10% of each stand. Due to the long, narrow shape of many of the stands, 5 of those selected were sampled at intensities greater than 10% (ranging from 11 to 22%).

RESULTS AND DISCUSSION

Stocking

The average stocking was 266 trees/ac for the 5 planted seedling stands after an average of 7.2 growing seasons, and 293 trees/ac for the 5 direct seeded stands after an average of 5.8 growing seasons (Table 2). However, the stocking levels obtained by planting seedlings were generally higher than those obtained by direct seeding. If Stand 7 (in which nearly twice the usual number of acorns was sown) is excluded, then the average stocking of the remaining 4 direct seeded stands drops to 137 trees/ac.

There are many reasons why the stocking of direct seeded stands might be lower than those planted with seedlings. Some of these include use of acorns of unsuitable genetic stock or low viability, rodent depredation, and inability of very small seedlings to withstand drought and/or weed competition.

It appears that the first three reasons do not apply in these stands. The seed was collected locally, and therefore should be of

Table 1. General characteristics of selected stands.

No.	Location	Species planted	Date of planting	Stand size (ac)	Initial no. planted/Ac[a]	Predominant soil type(s)	Comments
			Planted seedling stands				
1	Hillside NWR	Nuttall	2/84	13	360	Sharkey silty clay loam; Dundee silt loam	Stand was partially burned 2 or 3 years after planting
2	Yazoo NWR	Willow Water Cherrybark	3/82	32	360	Dundee silt loam	
3	Hillside NWR	Nuttall	1/84	9	360	Bruno sandy loam; Adler silt loam	
4	Hillside NWR	Willow Water Cherrybark	2/82	16	360	Dundee silty clay loam; Dundee silt loam	
5	Yazoo NWR	Willow Water Cherrybark	3/82	11	360	Dundee silt loam	
			Direct-seeded stands				
6	Panther Swamp NWR	Nuttall	4/84	28	1600	Sharkey clay; Forestdale silty clay loam	Acorns did not germinate until August of the first growing season
7	Panther Swamp NWR	Willow Water Nuttall	11/81	12	2700	Sharkey clay	
8	Hillside NWR	Shumard	2/84	6	1600	Morganfield silt loam	Weeds were controlled by bushogging and herbicides for first growing season
9	Hillside NWR	Shumard	3/85	8	1600	Adler silt loam	
10	Hillside NWR	Water	11/85	9	1600	Morganfield silt loam	

[a] These are target planting rates, but since planting spots were not premeasured actual planting rates are likely to vary somewhat both within and between stands.

appropriate genetic stock. Also, for one stand (No. 8), a regeneration check found at least 500 living seedlings per acre near the end of the first growing season (Larry Moore, USDA Forest Service, pers. comm.), indicating that at least in this case there was an acceptable proportion of viable acorns and little or no rodent depredation.

The same regeneration check (in Stand 8) found that an additional 70 seedlings per acre had germinated and then died, apparently because of drought stress. Since both bushhogging and herbicides had been used to control weeds in this stand during the first growing season, it is unlikely that many seedlings would have succumbed to weed competition, at least in the first year.

Drought-caused mortality may be an important factor on some of the soil types encountered in this study. The three stands with the lowest stocking (8, 9, and 10) were on either Adler or Morganfield silt loams, which have seasonal high water tables of about 20 inches and 36+ inches below the surface, respectively (Scott et al. 1975). Only the Bruno sandy loam has a deeper seasonal high water table level (40+ inches); its presence in Stand 3 may account for the lower stocking of Nuttall oak in Stand 3 than Stand 1, which was planted at the same spacing in the same year.

In contrast to the above soils, the Dundee silt loam type (Stands 1, 2, 4, and 5) has a seasonal high water table of 12 in., while that of

Table 2. Stocking and growth of planted oaks.

Stand	Species	Age[a]	Stocking (no./ac)	Mean dbh (in.)[b]	Mean height (ft)
			Planted seedling stands		
1	Nuttall	6	300	2.3	19
2	Cherrybark	8	60	0.5	5
	Willow		206	1.3	11
			266		
3	Nuttall	6	248	1.2	9
4	Cherrybark	8	35	1.2	10
	Water		168	2.0	16
	Willow		113	2.3	17
			316		
5	Cherrybark	8	16	0.5	4
	Water		177	0.9	9
	Willow		7	1.1	9
			200		
			Direct-seeded stands		
6	Nuttall	6	201	0.3	5
7	Nuttall	8	12	0.8	8
	Water		438	0.5	7
	Willow		464	0.6	7
			914		
8	Shumard	6	160	0.3	4
9	Shumard	5	102	0.3	3
10	Water	4	87	0.2	2

[a] Number of full growing seasons.
[b] Dbh of trees greater than 4.5 ft in height; trees of this height made up less than a third of the total stems in Stands 8, 9, and 10.

the Sharkey (Stands 1, 6, and 7) and Forestdale (Stand 6) soils is at the surface. Although all the soils on these sites (except the Bruno sandy loam) have high or very high available water capacity, the lower water table levels of the Adler, Bruno, and Morganfield soils may result in drought stress earlier and more often than on the other sites.

The stands that may be most prone to drought stress due to soil characteristics also tended to have the heaviest growth of weeds (Table 3), making it impossible to ascertain whether weeds or soil conditions had the biggest impact on survival. In particular, a heavy cover of Johnson grass and goldenrod seems to be associated with poorly stocked stands. These two species accounted for more than 50% cover in the two planted seedling stands with the lowest stocking (3 and 5) and more than 75% of the cover in the three direct seeded stands with the lowest stocking (8, 9, and 10).

Table 3. Percent cover of selected herbaceous species and woody vines.

Stand	Goldenrod[a]	Johnson grass[b]	Broom sedge[c]	Cocklebur[d]	Woody vines[e]
1	7	0	0	1	35
2	36	12	8	0	1
3	32	35	1	0	1
4	35	2	3	0	27
5	47	11	1	0	6
6	3	1	8	20	5
7	1	0	12	30	13
8	31	46	0	0	0
9	68	19	0	0	3
10	2	82	2	1	0

[a] *Solidago altissima.*
[b] *Sorghum halepense.*
[c] *Andropogon virginicus.*
[d] *Xanthium strumarium.*
[e] Primarily poison ivy (*Rhus radicans*) and trumpetcreeper (*Campsis radicans*).

Growth

Although direct comparisons were not possible because of differing ages, site conditions, and other uncontrolled variables, diameter and height growth were clearly better for the plantations established with seedlings (Table 2). For all species combined, average diameter growth of seedling stands was more than three times as much as direct seeded stands (0.19 vs. 0.06 in./year) and height growth was nearly twice as much (1.5 vs. 0.8 ft/yr). When planted on the same sites, Nuttall oak grew the fastest, followed by willow oak, water oak, and cherrybark oak.

Natural Invasion

Because natural invasion of other tree and shrub species is desired for wildlife management purposes (and may be undesirable for timber production), the number of invaders were recorded for each stand (Table 4). In 3 stands (1, 6, and 9), the number of invading trees and shrubs exceeded the number of planted trees, and in 2 stands (6 and 9) the average height of the invaders exceeded the average of the planted trees.

The number of invader species was highest in stands immediately adjacent to mature trees. Stand 1, for example, was a long narrow strip planted against a natural drainage lined with large trees. Stands 4, 6, and 9 were bordered on two sides by either a line of large trees or a tract of mature forest. The remaining stands were either not immediately adjacent to large trees or were rectangular and had large trees only along one of the shorter sides.

Light-seeded species were clearly the predominant invaders, especially sweetgum, green ash, and American elm. The high number of sweetgums in Stand 1 may be due in part to the fire that burned through part of the stand 2 or 3 years after planting, re-

Table 4. Number of invading tree species and shrubs per acre in descending order of total abundance.

Species	Stand no. 1	2	3	4	5	6	7	8	9	10
Sweetgum (*Liquidambar styraciflua*)	5801	20	1	3	3	57	13	5	1	2
Green Ash (*Fraxinus pennsylvanica*)	100	5	26	7	7	40	6	1	95	0
American Elm (*Ulmus americana*)	57	15	2	51	22	2	0	27	4	20
Sycamore (*Platanus occidentalis*)	167	0	1	8	0	0	0	0	0	0
Persimmon (*Diospyros virginiana*)	3	17	64	6	5	10	8	7	8	24
Black Locust (*Robinia pseudoacacia*)	0	2	0	0	0	121	10	0	0	0
Boxelder (*Acer negundo*)	5	1	0	15	0	0	0	3	75	29
Shrubs	1	0	0	11	1	29	45	1	3	2
Sugarberry (*Celtis laevigata*)	43	3	1	2	13	0	1	0	5	0
Honeylocust (*Gleditsia triacanthos*)	7	2	0	3	11	3	17	0	0	0
Water/Willow Oak	11	0	0	0	0	1	0	1	0	0
Misc. Tree Spp.	3	0	0	4	0	1	0	0	0	2
Red Maple (*Acer rubrum*)	0	0	3	2	0	0	0	1	1	2
Water Hickory (*Carya aquatica*)	0	0	0	0	0	2	4	0	0	0
Overcup Oak (*Quercus lyrata*)	0	0	0	0	0	0	5	0	0	0
Total	6198	65	98	112	62	266	109	46	192	81

ducing weed cover and exposing mineral soil (Larry Moore, USDA Forest Service, pers. comm.). Few heavy-seeded species, such as overcup oak and water hickory, had invaded any of the stands.

CONCLUSIONS

All ten of the stands are likely to eventually meet the objective of establishment of bottomland hardwood wildlife habitat with a minimal investment of time and money. Overall, however, the planted seedling stands had better stocking and growth than the direct seeded stands, and are closer to meeting the habitat establishment objective.

While the number of uncontrolled variables in this study rules out definitive conclusions, the results imply that planting seedlings is a better method for establishing bottomland hardwood forest habitat quickly on old field sites. Controlled comparative studies of planting seedlings and direct seeding on a variety of sites are needed to address this issue more completely. Also, studies designed to evaluate the relative benefits and costs of these two methods would be useful.

Site preparation and post-planting weed control probably would increase the survival and growth of direct seeded stands, but would also increase the overall costs of establishment, making this method less attractive. Planted seedlings were able to become well established without the benefit of either site preparation or post-planting weed control.

This author is unaware of any quantitative guidelines that can be used to assess whether adequate invasion of other tree species has occurred for wildlife habitat establishment purposes. Given the patterns of invasion that occurred on the ten study sites, however, planting additional heavy-seeded species may be desirable. Also, planting of some lighter-seeded species with particular value to target wildlife species may be necessary in stands isolated from mature trees. □

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